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FOREST INSECT INVESTIGATIONS

HOST SELECTION IN RELATION TO THE CONTROL OF BARK BEETLES

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The Question of Host Selection by D. monticolae

In attempting to review all of the evidence based on the correspondence and project reports of the various infestations of the mountain pine beetle in areas containing western white pine, white-barked pine, or ponderosa pine along with or adjacent to lodgepole pine it seems that it would be impossible to draw any definite conclusions as to the validity of the host selection principle as applied to this beetle. However, certain tentative conclusions might be advanced.

1. There is a decided tendency for Dm to become adapted to lodgepole pine to such an extent as to prefer it to other species. This is a tendency and is not a universal rule.

2. In strongly epidemic infestations in lodgepole pine where ponderosa pine was intermingled with or adjacent to the infested lodgepole (N.E. Oregon Project, Klamath-Lake Project) there was a greater or less (often alarming) infestation in the ponderosa pine. In both Oregon projects, the infestation in ponderosa pine ceased coincidentally with the passage of the lodgepole infestation.

3. From the documentary evidence, it would seem that in lodgepole-ponderosa pine areas, a few of the beetles attack the latter successfully and breed in it, but apparently still prefer lodgepole. In the So. Oregon area when the Paulina N. F. infestation ceased the adjacent ponderosa infestation went with it. New infestations were reported the following year in many lodgepole stands in So. Oregon and some of these may have started by migration from the Paulina. On the other hand infestations in both lodgepole and ponderosa pine may have died out due to local conditions. In the reports of the Idaho-Montana infestations scarcely any mention is made of losses in ponderosa pine.

4. There is some evidence to indicate that while Dm do breed in ponderosa pine they do not become so completely adapted to it as to prefer it to lodgepole pine or to continue aggressively in it after the latter has been destroyed. Also those which do attack show a perference for the smaller thin barked trees, and thus saplings which would be left in an epidemic of the Black Hills beetle are the very ones most commonly killed. No evidence was found in the reports to indicate that Dm becomes so thoroughly adapted to ponderosa pine as to prefer it to other hosts.

5. In the Idaho-Montana areas several serious infestations are reported in white pine as well as the widespread devastation in lodgepole pine. At the start Mr. Evenden inclined to the view that the white pine infestations were independent of those in lodgepole but preserved an open mind on the subject and in the last report on the Pete Creek project concludes that the annual reinfestation in white pine can only be explained by flight from lodgepole infestation a few miles away.

6. In the Yellowstone, Teton and Medicine Bow areas where the primary infestations were in white-bark pine, there has been no apparent migration to adjacent lodgepole pine. However, in the Uinta N.F., with a shortage in white-bark pine, infestation of nearby lodgepole was found.

7. There is thus some indication that Dm has a greater ability to adapt itself to white pine and white-bark pine than to ponderosa pine.

8. In a brief report by Keen in 1917 a few experiments seemed to indicate that, in the Ashland area, where there was a longstanding infestation in sugar pine and occasional infestation in ponderosa pine, the beetles, regardless of the host from which they actually emerged, showed a preference for sugar pine. The experiments were too few to be conclusive, but they are confirmatory of the impression obtained from a reading of the correspondence and reports, that while some Dm will breed in ponderosa pine, they do not acquire a preference for this species.

It should be remembered that the above impressions are derived entirely from the documentary evidence on file, by one who has some knowledge of bark beetles and their habits but who has never had an opportunity of observing in the field the particular species involved.

M. W. BLACKMAN

May 5, 1933

HOST SELECTION
IN RELATION TO THE CONTROL OF BARK BEETLES

Introduction

In the formulation of plans for the control of bark beetle epidemics, it becomes necessary to consider the possibility of these insects successfully changing from one species of hosts to another. Though some records based upon uncontrolled field observations are available, positive information on this matter is lacking. The importance of such a successful interchange of hosts can hardly be overestimated, and as rapidly as possible projects will be instituted at this station to secure more data relative to the host selection habits of destructive bark beetles. Some experimental work has already been performed from which suggested leads have been secured, and actual field projects will be instituted whenever possible to check the results secured through additional intensive caged experiments. The purpose of this memorandum on "Host Selection" is to summarize all available information and theories in order that future investigations can be adequately planned and directed.

"Host-Selection Principle"

During the past few years, the theory contributed by Dr. A. D. Hopkins, generally known as the "host-selection principle", has become prominent in the economic practice of forest entomology. This principle provides that individuals of a given insect species capable of breeding

in two or more hosts, will, under normal conditions, continue to select for attack that host species from which it originated. In extending this principle we have the host exerting sufficient influence upon the female insects to cause them to select the same tree or plant species for oviposition, in or upon which their own life cycle was passed. Such a host selection is believed to result in the development of distinct varieties or strains of the same insect, each having their own host preferences, but showing no different morphological characters. This theory is thought to have originated with Benjamin Walsh, who in 1865 published a paper in which he argued for the origin of insect races and species as a result of food isolation.

During the past few years the host-selection habits of a number of different insects have been intensively studied, and in a majority of cases the results have supported the principle advanced by Hopkins. It will be understood that such selection will be most in evidence under normal condition when there is no question as to the availability of different hosts. Under experimental conditions, or in the absence of the preferred host, the preference for this specific plant may not be sufficiently strong to prevent the selection of other available material.

Accepting the biological soundness of this principle, forest entomologists must turn to the task of measuring its value in the artificial control of bark beetles. It is obvious, of course, that this thought only applies to those species which attack and destroy more than one tree species. Under normal conditions it is often evident that such a selection does exist, but it is not known if this preference will prevail during abnormal conditions produced by serious epidemic when perhaps the

preferred host nears depletion. We know that with different species of Dendroctonus beetles which attack and destroy certain tree species, that such attacks only occur during what may be called abnormal conditions. For example, though Engelmann spruce is one of the many hosts of the mountain-pine beetle, it is very unusual to find this species attacked except when in association with groups of infested white pine during rather serious epidemics. Western larch is given as one of the hosts of the Douglas-fir beetle, and infested logs are of common occurrence. However, at this station there is but one record of a standing western larch being attacked by this insect, and that was only one tree standing in a group of infested Douglas-fir trees during a recent epidemic. Furthermore, within this group of infested trees rather heavy broods of insects were present in the Douglas-fir trees, but only a very light one was found within the western larch, which would seem to indicate still further that this tree species is not a favorable host of the Douglas-fir beetle. We have records of where the mountain-pine beetle has apparently been working for a number of years in stands of limber pine and whitebark pine, surrounded by uninfested lodgepole pine stands. Epidemics of the mountain-pine beetle in lodgepole pine have swept through stands of white pine and ponderosa pine, and though heavy mortality occurred in these two tree species, it was not as devastating as in the lodgepole pine stands and subsided soon after the lodgepole infestation had passed by.

HISTORICAL

There are not a great many references available relative to the variation in the host plants of insects. During the past few years some work has been done with different insects and a number of papers published. Though these studies have all contributed toward a better understanding of the problem of host selection in its relation to all species of insects, practically no intensive work has been directed toward the understanding of this problem in its relation to bark beetles. A bibliography of all known references is included in this report.

FIELD OBSERVATIONS

Northeastern Oregon Project:

A severe outbreak of the mountain-pine beetle was present in the lodgepole pine stands of the Wallowa and Whitman National Forests in 1910. Reports submitted at that time indicated that though the losses in lodgepole pine were tremendous, the damage to the more valuable ponderosa pine had not been so severe. Though the infestation in lodgepole had reached such a magnitude as to make any plan of control impossible, it was still considered feasible in the ponderosa pine stands, providing there was no danger of the beetles spreading to this host from the lodgepole pine infestation adjacent. On the basis that such a spread would not occur, control measures were instituted in the ponderosa pine stands in 1911 and subsequent reports from examinations made in 1912 and 1913 indicated a reduction of 85% with no reinfestation from the lodgepole pine along the adjacent higher elevations. These data would seem to offer rather positive guidance as to the future policy to follow with such

infestations. Though there is no question as to the validity of the reduction secured, there is some question as to the continued existence of the potential source of supply in the lodgepole pine stand, as information secured a few years later would indicate that the infestation in lodgepole subsided at the same time as that in the ponderosa pine.

Klamath Falls Project - Oregon:

There is no record at this station of this early effort to control an outbreak of the western pine beetle in ponderosa pine. This project was instituted in 1912, near Klamath Falls, Oregon, and its details are not familiar to the writer. However, it is recalled that in connection with this project there was also an associated or adjacent infestation of the mountain-pine beetle in lodgepole pine which was disregarded in the plan of control with no destructive results to the ponderosa stands for which protection was desired. As with the Northeastern Oregon project, it is difficult to make a final summation as the complete history of the lodgepole infestation is not known.

Blackfoot River Infestation - Montana:

In 1912, a severe outbreak of the mountain-pine beetle in lodgepole pine spread into the northern division of the Missoula National Forest from the Flathead Forest to the north. During the following eight years the outbreak spread southward through this portion of the forest destroying a very large per cent of the lodgepole pine. During this period a tremendous volume of ponderosa pine occurring along the boundary of the lodgepole type and in association with the lodgepole was killed by these insects. One can hardly explain the occurrence of these

attacks as coming from any other source than the lodgepole infestation. However, the ponderosa forests were not devastated as were the lodgepole, and as soon as the severe infestation in the latter species passed by, the outbreak in ponderosa pine promptly subsided, though the available supply of host material was not exhausted. From this record it would seem that though in this instance lodgepole pine was the preferred host, during the existing severe outbreak, ponderosa pine was attacked and destroyed as a result of a localized shortage of preferred lodgepole pine. On the other hand, it would also appear that ponderosa pine was not entirely favorable to this insect and that the change of hosts was but a temporary expedient, as the outbreak soon subsided with the elimination of the source of supply in lodgepole.

Bitterroot Infestation - Montana:

This example is a duplication of the Blackfoot River situation just described. A severe infestation of the mountain-pine beetle in lodgepole was discovered in 1924, and since that time has swept through the lodgepole pine stand of the Bitterroot Forest, destroying from 60-90 per cent of total volume. Similar to the Blackfoot River situation, a tremendous volume of ponderosa pine has been destroyed, but this devastation has not been as severe or complete as in the lodgepole pine types. Furthermore, as the infestation in lodgepole died down due to the destruction of suitable host material, the outbreak in ponderosa pine also subsided, though there was ample host material remaining. Again it would seem that during such severe outbreaks of the mountain-pine beetle in lodgepole, the insects will spread into adjacent ponderosa pine stands, but that the infestation in this species depends upon the lodgepole

epidemic for its maintenance. This theory is apparently the only one that can be adopted when the results of these outbreaks are analyzed, however, it is difficult to reconcile this position with the apparently normal insect broods which developed in the ponderosa pine during the Bitterroot epidemic. Did these broods return to lodgepole or were they incapable of attacking and destroying additional ponderosa pine? Further intensive study is necessary to answer these questions.

Pete Creek Infestation, Kootenai Forest - Montana:

A severe outbreak of the mountain-pine beetle has been present in a stand of lodgepole extending along the northern boundary of the Kootenai Forest since 1924. A few miles from where this outbreak was first reported there existed on the head of Pete Creek a stand of white pine containing some twenty million board feet. In 1925 the mountain-pine beetle was also found to be present in this white pine stand. Though between the white pine and the lodgepole infestation there was a strip of uninfested lodgepole some four or five miles in width, it was rather reasonable to assume that the white pine infestation originated from this source. However, to check on this possibility, control measures were instituted in the spring of 1926 to reduce the outbreak in white pine stand. During the summer of 1926 there were about the same number of trees infested as had been treated the previous spring. Control measures were again instituted in the spring of 1927 with about the same results. At this time there did not seem to be any question but that the reinfestation following control was coming from the lodgepole: however, in view of the white pine values at stake, work was again instituted in the spring of 1928. Again the 1928 reinfestation seemed to

indicate that further efforts to preserve this white pine stand were futile and the project was discontinued. However, though it still seems that no other conclusions could be drawn from this evidence, there are certain facts which have been disclosed during more recent years which must now be considered. It is now known that in several other similar white pine types, separated from the lodgepole pine infestation by a distance of twenty or more miles, outbreaks of the mountain-pine beetle occurred at the same time as the Pete Creek infestation. Did these other outbreaks in white pine all originate from the same source as the Pete Creek infestation? If they developed from local conditions peculiar to each area, why could not such conditions have prevailed in the Pete Creek area? Furthermore, we now find that the outbreak in lodgepole, which, subsequent to 1928, engulfed the Pete Creek white pine stand, has in that immediate area subsided, due to the lack of suitable host material, but that a large per cent of the white pine volume still remains. Though the assumed source of supply has been eliminated, there still exists an infestation of the mountain-pine beetle comparable in severity to that which is present in other white pine stands of the forest. Can one assume in opposition to the previously adopted theory that had the Pete Creek infestation been a part of the adjacent lodgepole pine infestation that the white pine loss should have been a great deal heavier? Or, if a secondary host of the lodgepole epidemic, will it subside now that the original source has died down? Again these are questions that can only be answered by intensive experimentation.

Yellowstone Park - Wyoming:

In the Yellowstone Park at all high elevations there are stands of whitebark pine which are bordered below by extensive areas of mature lodgepole pine. It has been known for the past two seasons that a rather serious infestation of the mountain-pine beetle is present within these whitebark pine areas. Though this outbreak has only been in an epidemic status for the past two or three years, the source of the infestation is not known. Either it originated from normal infestation within the area, or else the insects spread from adjacent infested forests. Regardless of this question as to the source of the infestation, the fact still remains that though epidemic conditions have existed within these stands for the past three seasons and that though there are lodgepole pine trees associated with and adjacent to the whitebark pine, there have been practically no lodgepole losses.

Teton National Park - Wyoming:

Practically the same situation exists within this park as in the Yellowstone. A rather severe infestation exists in the whitebark pine along the higher elevations, with no losses in the lodgepole pine stands below.

Medicine Bow National Forest - Wyoming:

During 1932 season, severe localized outbreaks of the Black Hills beetle were recorded in both whitebark pine and lodgepole pine. These outbreaks were some 20 or more miles apart and in each instance were confined to one host. Though there were no whitebark pines adjacent to the lodgepole pine infestation, there were plenty of unattacked lodgepole

pine in the whitebark pine outbreak, even though a shortage of the apparently preferred host existed.

Uinta National Forest - Utah:

An experiment is being conducted on this forest by Forest Service officials which will contribute towards a better understanding of the host selection principle under forced field conditions. An infestation of the Black Hills beetle has been present within an isolated patch of whitebark pine for the past three years, during which period a large per cent of the pine has been destroyed. Surrounding the area of whitebark pine is a mixed stand of lodgepole and Douglas fir. In the fall of 1931 and spring of 1932, this mixed timber type was very thoroughly surveyed and all infested lodgepole pine thoroughly treated. During the summer of 1932 an additional number of lodgepole pine trees were infested, several of them being nearly a mile away from the nearest infested whitebark pine. If the insects did spread from the whitebark pine to lodgepole, which would seem to be a logical conclusion to draw, then it is evident that when a shortage of the preferred host exists as a result of epidemic conditions, that the insects will successfully attack other hosts. Will the infestation continue in lodgepole pine after the whitebark pine has been destroyed, is a question yet to be settled.

CAGED EXPERIMENTS CONDUCTED DURING 1932 SEASON

With the idea of more complete and detailed work in the future, a few caged experiments were conducted during the 1932 season. This work was under the field supervision of Mr. W. D. Bedard, and the following

paragraphs are copied from his report "Additional Information Concerning the Biology and Habits of the Mountain-Pine Beetle in Western White Pine" of January 28, 1933.

"On July 6, 1932, a square wire-screen cage was constructed in an infested area of forest and ten square feet of infested white-pine bark were placed in the center of the cage. Then four-foot sections from green trees were placed in each of the four corners; one section from white pine, one from whitebark pine, one from lodgepole pine, and one from Engelmann spruce.

"Beetles began emerging from the infested material on July 25, and after that date a total of 337 new adult beetles collected from white pine were liberated in the cage from time to time to insure a plentiful supply of beetles. As soon as beetles began emerging from the infested material, the white-pine log was attacked, but no attacks appeared in the other logs. On the sixth day after the first emergence, the white-pine log was removed from the cage and examined. After removal of the white-pine log, the beetles seemingly had no desire to attack the other three logs, but finally, after three days of crawling about on the screen, attacks began to appear in these logs. On August 15, 1932, the three remaining logs were examined. The following table gives the results of this study.

TABLE IV

ATTACKS BY D. MONTICOLAE IN VARIOUS HOST MATERIALS

Tree species	Date of first attacks	Date of removal of log	Number of attacks	Number of beetles
White pine	July 25	July 30	63	113
Engelmann spruce	Aug. 2	August 15	56	112
Lodgepole pine	Aug. 2	August 15	47	67
Whitebark pine	Aug. 3	August 15	11	13
	Crawling on sides of cage			62
	Dead in duff			29

"From examination of Table IV it would seem that there is a decided preference shown by the mountain-pine beetle in its selection of a host, white pine being preferred, when the beetles emerge from white pine; with Engelmann spruce, lodgepole pine and whitebark pine preferred in the order named. However, it is obvious that the data are entirely too meagre to use as a basis for any definite statements, but I believe they show sufficient results to warrant plans for more extensive experiments on this subject during the 1933 field season. Studies of this nature should be augmented by field observations and experiments in which infestations in one tree species are allowed to grow and watched for spread into other species."

PLANS FOR 1933 CAGING EXPERIMENTS

Tentative plans have been made, subject to the approval of the Washington office, for a complete system of cages to secure detailed information concerning host selection. These plans will be instituted during the 1933 season and call for approximately 14 cages which include experi-

ments with the mountain-pine beetle in western white, lodgepole, ponderosa, and whitebark pines, and in Engelmann spruce. Arrangements have also been made to place the cages under varying light and wind conditions as well as to use host materials which possibly have different degrees of attractiveness to the insects.

Respectfully submitted,

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